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Indian Standard

(Reaffirmed 1998)

METHODS OF TEST FOR COMMERCIAL BLASTING EXPLOSIVES AND ACCESSORIES

PART 4 DETONATING FUSES

(First Revision)

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INDIAN STANDARDS INSTITUTION
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METHODS OF TEST FOR COMMERCIAL BLASTING EXPLOSIVES AND ACCESSORIES

PART 4 DETONATING FUSES

(First Revision)

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Indian Standard

METHODS OF TEST FOR COMMERCIAL BLASTING EXPLOSIVES AND ACCESSORIES

PART 4 DETONATING FUSES

(First Revision)

0. FOREWORD

0.1 This Indian Standard (First Revision) was adopted by the Indian Standards Institution on 30 March 1984, after the draft finalized by the Explosives and Pyrotechnics Sectional Committee had been approved by the Chemical Division Council.

0.2 The Sectional Committee while reviewing this standard decided to revise it incorporating a test for the determination of sensitivity of the detonating fuse after waterproofness and flexibility tests. Certain modifications in the Dautriche method for the determination of velocity of detonation and in the determination of mass of explosive core for encapsulated detonating fuse for achieving more accurate results have been introduced.

0.3 Testing of commerical explosives is of utmost importance for ensuring their safety during transport and handling, stability in storage and adequate life and performance under all conditions of use. Test methods included in this standard cover these aspects for all the groups of explosives under consideration.

0.4 Depending upon the origin/production of the explosives stores, a large number of test methods are in vogue, which though similar in nature, differ in minor details of experimental procedure and expression/ interpretation of results.

0.5 It is a difficult task to select a particular method as the best one. Therefore, choice has been effected in favour of those methods, for which sufficient experience and experimental data is available and which are mutually acceptable to all concerned, namely, the producers, the inspection agencies and the consumers in the field.

0.6 The test methods cover both general and permitted explosives and accessories like detonators, detonating fuses and safety fuses. All items are not covered but only those have been included which are currently used and manufactured in the country. The methods are covered under different parts of this standard as follows:

Part 1 Gun powder (black powder)

Part 2/Section 1 Explosives, general

Part 2/Section 2 Explosives, permitted

Part 2/Section 3 Explosives, slurry

Part 3 Detonators, general and permitted

Part 4 Detonating fuses

Part 5 Safety fuses

0.7 In reporting the results of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS : 2-1960*.

1. SCOPE

1.1 This standard (Part 4) prescribes the methods of test for detonating fuses.

2. TERMINOLOGY

2.1 For the purpose of this standard, the definitions prescribed in IS : 10081-1981† shall apply.

3. TEST METHODS

3.1 Visual Examination — The detonating fuse shall be visually examined for smoothness, pliability and surface blemishes.

3.2 Determination of Diameter — The diameter shall be measured with the help of a micrometer or callipers. The instrument shall be preferably a ratchet type or spring loaded. Take 1 m length of sample and measure the diameter at three different places and at each place in two positions right angle to each other. Record the results giving the diameter of the detonating fuse in millimetres.

*Rules for rounding off numerical values (*revised*).

†Glossary of terms relating to commercial explosives, pyrotechnics and blasting practices.

3.3 Test for Flexibility and Sensitivity After Flexibility Test

3.3.1 *Test for Flexibility*

3.3.1.1 *At low temperature* — Take 1 m length of the sample and keep it in a chamber at a temperature of —10°C for 4 hours. Take out the fuse from the chamber after this period and quickly make 5 knots on the fuse 15 cm apart. Examine the surface of the fuse visually for any crack on the outer covering and record the number of cracks noticed in the sample.

3.3.1.2 *At high temperature* — Keep 1 m length of the sample in an air-oven at a temperature of 50°C for 24 hours. Take out the fuse and make 5 knots 15 cm apart quickly. Examine the surface of the fuse for any crack on the outer sheath and record the number of cracks noticed on the sample.

3.3.2 *Sensitivity After Flexibility Test*

3.3.2.1 *Apparatus*

a) *Lead plate* — 40 × 6 × 1·25 cm

b) *No. 6 strength detonator*

3.3.2.2 *Procedure* — Take the fuse after completing the visual tests (*see* **3.1**), lay about 5 cm of its one end over the lead plate and retain it with the help of adhesive tapes. Detonate the fuse from the other end and record if the full length of the fuse has detonated and whether the end portion has left any burning mark in the lead plate.

3.4 Test for Waterproofness and Sensitivity after Waterproofness Test

3.4.1 *Test for Waterproofness*

3.4.1.1 *Apparatus*

a) *Water pressure test vessel* — It consists of a steel cylinder of 25 cm internal diameter and about 1·5 m long which can be filled with water and maintained at any pressure up to 4 kg/cm^2 and provided with a pressure gauge.

b) *Copper or aluminium cups* — About 6 mm internal diameter and 25 mm length.

3.4.1.2 *Proeedure*

a) Take 1·5 m length of the fuse to be tested ensuring that the ends are squarely cut. Melt two parts of bitumen with one part of ceresine wax in a boiling water-bath. By means of a pair of tongs immerse the copper cup in the mixture and fill it to the

brim. Allow the mixture to cool for a few seconds, introduce the end of the fuse into the cup and allow the mixture to solidify. Redip the cupped end of the fuse into the sealing mixture, withdraw and allow it to cool. Alternatively, one can crimp the metal cup on to the fuse by suitable crimper to provide water proof seal. Follow the same procedure for sealing of the other end of the fuse.

b) Take the fuse with sealed ends and lay it longitudinally inside the vessel with ends of the fuse vertical. Fill the vessel with water in such a way that the sealed ends are always above the water surface. Subject the sample to a water pressure. The limit of pressure and duration shall be as specified in the relevant material specification. At the end of the period, take out the fuse, wipe dry of water and pierce it with a sharp pin at various points and then twist it to see if any water oozes out through these holes. If any water comes out, slitting of the fuse and examining the PETN for water absorption as given below in (c) would not be required.

c) In case no water oozes out in (b) above, then cut a piece of the fuse 1 m long and examine the explosive core for any water absorption.

3.4.2 *Sensitivity After Waterproofness Test*

3.4.2.1 *Apparatus*

a) *Lead plate* — 40 × 6 × 1·25 cm

b) *No. 6 strength detonator*

3.4.2.2 *Procedure* — Take the fuse after completing the visual tests in **3.1**, lay about 5 cm of its one end over the lead plate and retain it with the help of adhesive tapes. Detonate the fuse from the other end and record if the full length of the fuse has detonated and whether the end portion has left any burning mark in the lead plate.

3.5 Determination of Velocity of Detonation (VOD) by Microtimer

3.5.0 *General* — The time taken by the detonation front to traverse a known distance in the fuse is measured by a timer in microseconds. Thus, the velocity of detonation (VOD) is expressed as metre per second.

3.5.1 *Apparatus*

3.5.1.1 *Microtimer* — The microtimer is an electronic instrument which is suited for measuring very short time intervals such as those involved in detonation processes. Two signals which define the beginning

and end of the time interval to be measured are used as 'start' and 'stop' signals to operate a gate. This gate turns on and off a constant current supply to a capacitor and the voltage developed across the capacitor is measured by an electrometer-voltmeter circuit. Thus, if the capacitor starts with zero potential difference across it, the potential registered by the voltmeter circuit at the end of the time interval is directly proportional to the time interval. By suitably selecting the various circuit constants the voltmeter is made to read directly in microseconds.

3.5.2 *Procedure*

3.5.2.1 *Preparation of VOD probes* — Take four pieces of enamelled copper wire of 0·32 to 0·56 mm diameter, each of 60 cm length. Pick up two enamelled wires at a time and twist together one end of each of the wires over 3 to 4 cm length. Remove the insulations of the free ends of the wires. These wires twisted together should have an electrically open circuit. The twisted wires with the bare ends are called 'VOD probes'.

3.5.2.2 *Preparation of test sample* — Take a 50 cm long sample and mark two points 10 cm apart at 30 and 40 cm from one end. Insert the 'start probe' at the point at 30-cm mark and 'stop probe' at 40 cm mark.

3.5.2.3 *Operation of the microtimer* — The test sample as prepared in **3.5.2.2** is detonated suitably and the interval of the propagation of the detonation wave between the two probes is measured on the microtimer. Attach an electric detonator to the 'start end' of the detonating fuse by means of adhesive tape and fire by a suitable exploder.

In case of firing with safety fuse, take a length of freshly cut safety fuse, insert one end of this into a detonator and crimp the detonator into the fuse using a crimper. Attach the detonator on to the detonating fuse near the 'start end' using adhesive tape.

3.5.2.4 *Precautions* — The following precautions shall be observed:

a) Keep the timer key and exploder key (in case of firing by exploder) always in possession while connecting the detonator to the shotfiring cable;

b) In case of incomplete detonation, carefully collect all the fragments of the charge;

c) In case of misfire, wait at least for 10 min in case of shot firing electrically or for at least 30 min in case of shotfiring with safety fuse before approaching the shot; and

d) The timer shall be calibrated once in 6 months.

3.5.3 *Calculation*

$$\text{Velocity of detonation (VOD), m/s} = \frac{d}{t} \times 1\,000$$

where

d = distance in mm between the probes, and

t = time in microseconds taken for the wave to travel.

3.6 Determination of Velocity of Detonation (VOD) by Dautriche Method

3.6.0 *General* — The method is similar in principle to the Dautriche method for blasting explosives, the only difference being that in case of VOD measurement of detonating fuse, a standard detonating fuse of known VOD is taken as the time standard and the detonators at each end of the standard are kept in contact with the test sample by metal T-unions.

3.6.1 *Apparatus*

3.6.1.1 *Lead plate* — 40 × 6 × 1·25 cm.

3.6.1.2 *Standard detonating fuse of known velocity*

3.6.1.3 *No. 6 strength detonator*

3.6.1.4 *T-shaped copper/brass unions*

3.6.1.5 *Ordinary detonators*

3.6.1.6 *Safety fuse*

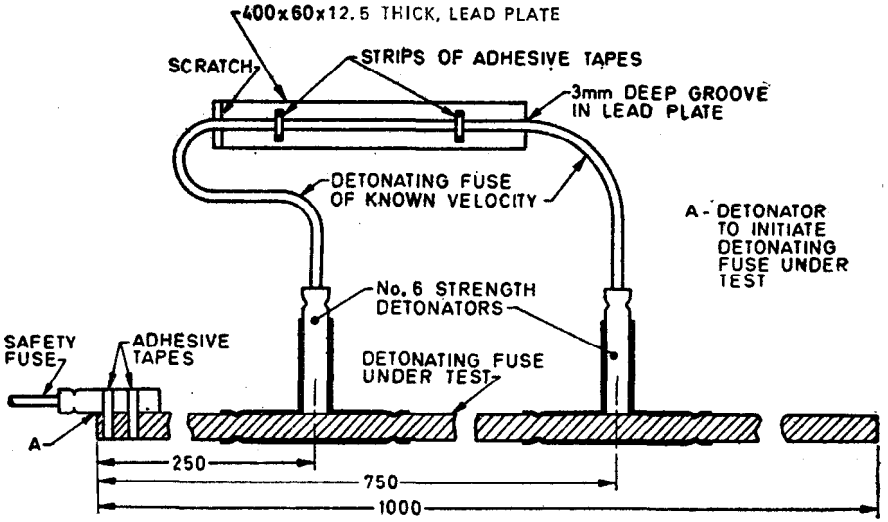
3.6.2 *Procedure*

3.6.2.1 Cut a 100-cm length of the detonating fuse and mark on it accurately with pencil two points 25 cm and 75 cm from one end. Slide two copper T-unions along the test sample until the centre of the vertical limb of each union is directly above one of the marks. Secure each T-union in position by means of a light crimp as shown in Fig. 1

3.6.2.2 Take a lead plate of the dimensions given in **3.6.1.1.** Along the length of the plate, in the centre, cut a groove 3 mm deep. Using a sharp knife, make a scratch along the whole width at one end of the plate about 10 mm from the edge. Take 1 m of the standard detonating fuse of known velocity and mark its middle point by a pencil. Lay the standard detonating fuse along the groove of the lead plate in such a way that its middle point is in line with the scratch made on the end of the plate. Retain the detonating fuse in position on the lead plate by using strips of adhesive tape. Insert the ends of this detonating fuse,

one in each of the vertical limb of the T-union so that the ends are in contact with the test sample. Crimp lightly the ends of vertical limb of the T-union near the open end. Take an ordinary detonator and crimp a length of half metre of safety fuse to it. Secure this detonator to one end of the test sample by means of adhesive tape. Light the safety fuse and retire to safe distance. After the system is detonated, recover the lead plate and measure the distance of the mark on the plate (made at the meeting point of the two detonation fronts travelling in opposite directions in the standard detonating fuse) from the scratch made on the wider end.

NOTE — The point of meeting of detonation wave will be seen more clearly on the reverse of the plate. For initiation of the detonating fuse, electric detonator can also be used.



All dimensions in millimetres.

FIG. 1 APPARATUS FOR DETERMINATION OF VELOCITY OF DETONATOR BY DAUTRICHE METHOD

3.6.3 *Calculation*

$$\text{Velocity of detonation (VOD), m/s} = \frac{d\,V_o}{2\,\Delta\,L}$$

where

d = distance in cm between the two pencil marks on the sample;

V_o = VOD of the standard detonating fuse in m/s, and

$\triangle L$ = distance in cm between the middle point of standard detonating fuse (scratch on the lead plate) to the point on the lead plate where the two detonation fronts travelling in opposite directions meet.

3.6.4 *Precautions* — The following precautions shall be observed:

a) In case of misfires with electric firing, wait at least for 10 min and in case of safety fuse firing, wait at least for 30 min before approaching the test charges; and

b) Destroy the misfired detonating fuse sample or detonator by using a fresh detonator.

3.7 Test for Transmission of Detonation

3.7.1 *Procedure* — Take 6 sample of 4 m each. Take one sample as the main line and to this tie the other samples by clove hitch knots at 1 metre intervals and at an angle of 60° to form five branch lines as shown in Fig. 2. Detonate the main line using a No. 6 strength detonator and record the result giving the particulars of the detonating fuse and the number of branch lines detonated.

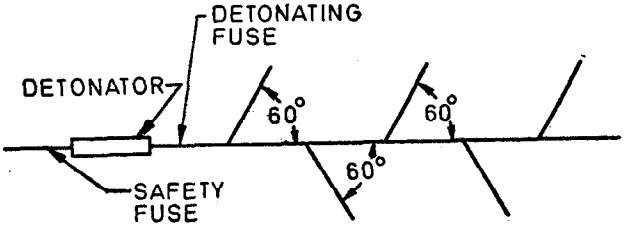


FIG. 2 TRANSMISSION OF DETONATION

3.7.2 *Precautions* — Follow the same precautions as given in **3.6.4.**

3.8 Determination of Mass of Explosive Core

3.8.1 *Apparatus*

3.8.1.1 *Soxhlet apparatus* — complete with condenser.

3.8.2 *Reagent*

3.8.2.1 *Acetone* — *see* IS : 170-1976*.

*Specification for acetone (*second revision*).

3.8.3 *Procedure*

3.8.3.1 *For ordinary detonating fuse* — Cut a 20 cm long sample of the detonating fuse. With a sharp blade, cut lengthwise the PVC layer and peel it off making sure that no PETN is sticking to the PVC. Hold the fuse over a filter paper thimble and gently tap the PETN from the yarn core into the thimble. Then add the yarn over the PETN and assemble this in the extractor of the Soxhlet apparatus. Place 250 ml of acetone in the flask which has been tared and set it on a water-bath and extract for about one-and-a-half hours. At the end of the period remove the flask, evaporate the acetone to dryness on a water-bath and dry the flask in an oven at 60°C for about an hour. Cool in a desiccator and weigh. Conduct the blank using the same length and quality of the yarn as used in the making of the detonating fuse. Subtract the mass of the extract obtained from the yarn from the mass of the PETN extracted from the detonating fuse. Calculate the mass of PETN in one metre of the detonating fuse.

3.8.3.2 *For encapsulated detonating fuse* — Take 25 cm of the detonating fuse sealed at both ends with adhesive tape and weigh it accurately (*A*). With a sharp blade/knife, slit it open in such a way that only the outer covering is cut. Peel this covering off carefully and keep it aside. Take out the inner yarns, plastic covering, if any, paper/plastic tape, etc, carefully, brush these to free any PETN sticking to those and keep aside. Weigh the plastic covering, yarns, inner covering the tape, etc, together (*B*). From the difference in the mass (*A*) and (*B*), the PETN charge mass is calculated.

NOTE — By this method, error arising out of PETN loss due to spillage, while taking out of the fuse to determine the charge mass could be minimised.

3.9 Determination of Breaking Load of Live Detonating Fuse

3.9.0 *Outline of the Method* — The ends of a small length of detonating fuse are secured to two separate holders (as shown in Fig. 3) provided with hooks. To one of the holders is attached the required weight. The whole assembly consisting of knurled holders, fuse and weights is lifted off the ground by a suitable arrangement in such a way that the holder with the weight is vertically below the other holder with the fuse stretched tightly between them and under tension on account of the weight attached to the bottom holder. The load at which the fuse breaks within 20 seconds of suspension is taken as the breaking load.

NOTE — It is presumed that the weight of the bottom holder and the hook will be small and negligible as compared to the load required for breaking. However, for the sake of correctness of the method, the same may also be taken into account.

3.9.1 *Procedure*

3.9.1.1 Cut a length of fuse 175 ± 1·25 cm long and seal ends with adhesive tape. Thread one end of this length through the holes in the knurled holders marked 'top' and tie a simple thumb knot in the end of the fuse. The holder shall be held with the shank position vertical, the hook facing left and the circular portion away from the tester. The end of the fuse is threaded outside to inside of the circular portion through the hole marked 1 and then inside through hole 2. The knot is then tied on the outside of hole 2.

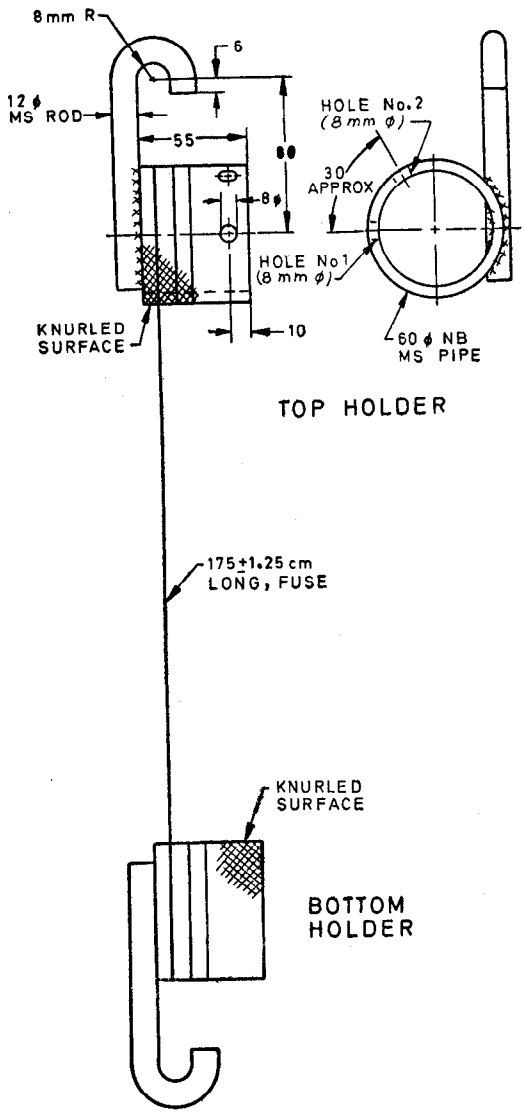
3.9.1.2 *Outside of hole 2* — Pull the fuse until the knot is tight against the 'holder' and then wind the fuse twice through the knurled circular portion in the direction of the arrow. The fuse shall lie flat and not cross or kink.

3.9.1.3 Place the holder carefully on the bench, still holding the fuse in position. Using a pen, put a mark on the fuse opposite the mark near the bottom of the shank of the knurled holder. Measure 30 cm from this mark along the length of the fuse as accurately as possible using a ruler and again mark the fuse at this point.

3.9.1.4 Place the fuse with this mark opposite the mark near the bottom of the shank of the other holder. The hook of the other holder is provided with a base plate to which required weights could be slipped in as desired. The mass of the base plate is also to be taken into account. The base plate is supported on a jack before the start of the experiment. The jack is operated from outside the cell by a long handle. Additional weights are placed/removed on the base plate as required. The top holder is left lying on the bench so that the fuse remains loosely coiled in position and it is necessary to take care not to disturb this position while connecting the fuse to the other holder. It is convenient to hold the other holder with the shank portion horizontal and on the left, the hook facing towards the right, the circular portion facing vertically downwards and in such a position that when the free end of the fuse is wound around the knurled circular portion, the hooks on each holder will be at opposite end of the whole assembly.

3.9.1.5 Wind the free end of the fuse twice around the knurled circular portion of the holder and then thread the end through hole No. 1 from outside to inside and out through hole 2.

3.9.1.6 Tie a simple thumb knot in the end of the fuse and pull this knot tight against the outside of the holder. Carry out the assembly to the test cell and place it carefully on the floor so that the fuse remains in position on the holders.



All dimensions in millimetres.

FIG. 3 DETONATING FUSE BREAKING LOAD TEST ASSEMBLY

3.9.1.7 Place the required weight on the equipment. If the approximate breaking load is known, place weights to give 5 kg below the breaking load for the first test. If the breaking load is unknown start with a 25-kg load.

3.9.1.8 Connect the test assembly to the hooks provided, ensuring that the fuse stays on the holder in the correct position. The 'top' holder shall be connected to the top hook and the other holder to the hook on the base plate carrying weight.

3.9.1.9 Proceed outside the cell and wind the handle provided to operate the jack in a clockwise direction until the weight is lifted clear of the floor. Check the time at this instant and allow the weight to remain suspended for 20 seconds, if the fuse does not break. The fuse will be stretched and it is, therefore, necessary to continue winding for a time to keep the weight clear of the floor.

3.9.1.10 If the fuse does not break after 20 seconds suspension, wind the handle in an anti-clockwise direction until the base plate rests on the floor and tension is fully removed.

3.9.1.11 Re-enter the cell and remove test assembly from the hooks.

3.9.1.12 To begin with, take one piece each time and go on increasing the weight till the fuse snaps. Reduce the weight by 5 kg. Make 3 determinations to know whether the fuse stands that weight, if any one of them shows a failure, go down further by 5 kg steps till the fuse stands the test in all the 3 determinations with a fresh piece of fuse each time. Report the mass in kg at which the fuse breaks as the breaking load to the nearest 5 kg.

3.9.1.13 *Precautions* — Take all the usual precautions for testing explosives. It is advisable to keep the apparatus inside a building and observations made from outside. However, if the observations are also made inside, the operator should be protected during the test by interposing a 6 mm thick mild steel shield between the operator and the machine.

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

Quantity	Unit	Symbol
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

Quantity	Unit	Symbol
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

Quantity	Unit	Symbol	Definition
Force	newton	N	1 N = 1 kg.m/s^2
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m^2
Frequency	hertz	Hz	1 Hz = 1 c/s (s^{-1})
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 N/m^2

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